Sta 5
FEB 03 1999

12

ENGINEERING DATA TRANSMITTAL

Page 1 of 1
1. EDT 623018

2. To: (Receiving Organization) B&W Hanford Company		3. From: (Originating Organization) FDNW Criticality and Shielding		4. Related EDT No.: N/A	
5. Proj./Prog./Dept./Div.: Plutonium Finishing Plant		6. Design Authority/ Design Agent/Cog. Engr.: D. M. Fazzari		7. Purchase Order No.: N/A	
8. Originator Remarks: Approval/Release				9. Equip./Component No.: N/A	
				10. System/Bldg./Facility: 234-5 Z	
11. Receiver Remarks:		11A. Design Baseline Document? ☒ Yes ☐ No		12. Major Assm. Dwg. No.: N/A	
				13. Permit/Permit Application No.: N/A	
				14. Required Response Date:	

15. DATA TRANSMITTED					(F)	(G)	(H)	(I)
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	Approval Designator	Reason for Transmittal	Originator Disposition	Receiver Disposition
1	HNF-3499	-	0	CSER 98-009: Antech Neutron Multiplicity Counter for Nondestructive Analysis	S	1,2	1	
16.				KEY				

Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN
1	1	Design Authority	R. W. Szmpruck	2/2/99	75-44	1	1	Orig. Engr.	H. J. Goldberg	2/2/99	B4-44
1	1	Design Agent	A. L. Ramble	2/2/99	75-54	1	1	Orig. Mgr.	J. P. Estrellado	2/2/99	B4-44
1	1	Cog. Eng.	C. H. Fazzari	2/2/99	75-06	1	1	Tech. Review	D. G. Erickson	2/2/99	B4-44
1	1	Cog. Mgr.	E. W. Curfman	2/2/99	75-05	1	1	Independent Review	A. J. M. [Signature]	2-1-99	B4-44
1	1	Safety	S. E. Nunn	2/2/99	75-11	1	1	CSE	R. F. [Signature]	2-1-99	B4-44
1	1	CSR	M. E. Shaw	2/1/99	75-54						

18. H. J. Goldberg Signature of EDT Originator Date: 12/2/99		19. A. L. Ramble Authorized Representative Date for Receiving Organization Date: 2/2/99		20. R. W. Szmpruck Design Authority/ Cognizant Manager Date: 2/2/99		21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments	
--	--	---	--	---	--	---	--

CSER-98-009: ANTECH NEUTRON MULTIPLICITY COUNTER FOR NONDESTRUCTIVE ANALYSIS

5

H. J. Goldberg

Fluor Daniel Northwest, Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 623018

UC: 610

Org Code: 403

Charge Code: 101417/AJ60

B&R Code: EW7002010

Total Pages: 27 29 *add 2/3/99 per telecom dp*

Key Words: NDA, PFP, Plutonium

Abstract: The ANTECH Multiplicity counter has been examined for normal and off normal conditions with respect to criticality reactivity.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

H. J. Goldberg
Release Approval

2/3/99
Date

Release Stamp

Approved for Public Release

**CRITICALITY SAFETY EVALUATION REPORT 98-009: ANTECH NEUTRON
MULTIPLICITY COUNTER FOR NONDESTRUCTIVE ANALYSIS**

Prepared by: Date: 15 January 1999
H. J. Goldberg
Criticality and Shielding

Reviewed by: Date: 1-15-~~98~~ 99 dec
D. G. Erickson
Criticality and Shielding

Approved by: Date: 1/15/99
J. P. Estrellado, Jr, Manager
Criticality and Shielding

Table of Contents

1.0 INTRODUCTION AND SUMMARY	1
1.1 Summary	1
1.2 Expected Operations	1
1.3 Expected Normal Conditions	2
1.4 Limits	6
2.0 SYSTEM DESCRIPTION	7
3.0 METHODOLOGY	7
4.0 SAFETY EVALUATION	9
4.1 Base Case Conditions	10
4.2 Contingency Analysis	11
5.0 CHECKLIST FOR REVIEWS	14
6.0 REFERENCES	18
7.0 COMPUTER INPUT DECKS	20

CRITICALITY SAFETY EVALUATION REPORT 98-009

**ANTECH¹ NEUTRON MULTIPLICITY COUNTER FOR
NONDESTRUCTIVE ANALYSIS**

1.0 INTRODUCTION AND SUMMARY

The ANTECH neutron multiplicity counter is a portable nondestructive assay (NDA) instrument which measures plutonium content by counting fission neutrons in the presence of (α ,n) neutrons. Neutrons from the (α ,n) process are discriminated against through the use of coincidence counting. The instrument will be used for the purpose of determining inventory of plutonium in the Plutonium Finishing Plant (PFP). The portability of the instrument will facilitate this task by minimizing the necessity of transporting fissile material.

The use of the Antech neutron multiplicity counter is authorized under the categories NEUTRON WELL COINCIDENCE COUNTERS and PORTABLE COUNTERS in the typical equipment list in CPS-Z-165-80120 Rev/Mod B-5 (CPS,1997). This criticality prevention specification (CPS) requires that new NDA detectors be evaluated by Criticality and Shielding before being used. This CSER has been prepared in compliance with this requirement.

1.1 Summary: The use of the Antech counter is approved based on the inherent safety of the containers to be assayed in that an acceptable margin of subcriticality has been demonstrated for all normal and credible abnormal conditions in accordance with HNF-PRO-537 (HNF, 1997). A summary of the results of the abnormal conditions are tabulated in Table 2. For foreseeable contingencies, the calculated k_{eff} s are less than 0.95 after taking into account the calculational bias and statistical uncertainty equal to or larger than the 95% confidence level. This approval is based on the requirement that only one container is to be put in the counter at a time and in accordance with the other limits listed in section 1.4. The design of the current instrument conforms with the acceptability criteria which allow the other NDA detectors currently employed at the facility to be safely used.

1.2 Expected Operations: This neutron multiplicity counter will be used at PFP to assay containerized material for plutonium content one container at a time in a dry sample chamber. This and the next section are in accordance with standard double contingency documentation.

¹ ANTECH is a registered trademark of Antech Corporation

1.3 Expected Normal Conditions: Doubly contained source material not to exceed 2.5 kg if $H/Pu \leq 2$ and $vol \leq 2.7 \ell$, 1.5 kg if $H/Pu \leq 20$ and $vol \leq 2.7 \ell$, 400 g for unlimited H/Pu ratios and $vol \leq 4.7 \ell$, and 1 kg for unlimited H/Pu ratios and $vol \leq 0.5 \ell$. One can will be introduced into the instrument at a time and no other fissile material is to be within three feet of the sample chamber. The expected base case is tabulated in Table 1.

Table 1: Antech Neutron Multiplicity Counter for PFP - Base Case Summary

Controlled Parameter	Limit	Abnormal but Anticipated Conditions (Conservatism for Analysis)
Mass	2.5 kg if $H/Pu \leq 2$ and $vol \leq 2.7 \ell$, 1.5 kg if $H/Pu \leq 20$ and $vol \leq 2.7 \ell$, 400 g for unlimited H/Pu ratios and $vol \leq 4.7 \ell$, and 1 kg for unlimited H/Pu ratios and $vol \leq 0.5 \ell$.	Analyses were carried out with 100% ^{239}Pu
Volume	Limited by container, cavity geometry, and administrative volumetric and mass limits. Also, no damaged cans are allowed.	Volume determined by size and density of limiting case, i.e. Pu button
Geometry	Limited by container and cavity geometry	Pu Button is most reactive
Moderation	Mass and moderation limits interrelated (See mass limits)	Bounding Mass/Moderation Combination is dry, double batched Pu buttons
Interaction	Three foot spacing	Cadmium shield not included in the calculations.
Reflection	Not Applicable ²	Bound Reflection with close fitting Water
Density	Not Applicable	Theoretical Density for Metal; Greater than Theoretical Density used for Oxide
Material Form	No limit on Material Form	Pu metal bounds other forms
Concentration	Not Applicable	Pu metal buttons bounding for mass limits
Poisons	Not Applicable	Analyses do not include steel from containers and 100% ^{239}Pu used.
Enrichment	No limit on Enrichment	100% ^{239}Pu bounding

²Multiple canning of fissile material is an engineered barrier to close fitting reflection and the NDA sample chamber is an engineered barrier to close fitting polyethylene reflection.

Table 2: Antech Neutron Multiplicity Counter for PFP -Contingency Summary			
Contingency Description	Affected Parameter(s)	Barriers that Make Contingency Unlikely	K_{eff} Bounding Contingency (Case ID)
One Container (10.8 cm dia x 17.78 cm ht)* with flooded chamber.(2.5 kg Pu button)	Reflection	Cover on counter (not completely watertight), Bottom plug is not completely watertight	0.730 ± 0.003 (CSAR 80-027, Add. 3, Case Calrim0il)
Double batched container (10.8 cm dia x 17.78 cm ht)* (5 kg total Pu metal)	Mass limit	Operator Training, Mass control on original loading of can	0.887 ± 0.003 (CSAR 80-027, Add. 3, Case Calrim0h)
Water both in container and chamber (Since all containers are filled with water, the container size is irrelevant to this table) (2.5 kg Pu button)	Reflection	Cover on counter (not completely watertight),Bottom plug is not completely watertight, Fissile material is doubly contained	0.777 ± 0.003 (CSAR 80-027, Add. 3, Case Calrim0jl)

Note that all masses in the table above are made up of 2.5 kg Pu metal buttons.

* Sizes are outer container sizes. The inner container is 8.57 cm dia. x 5.08 cm ht.

Contingency Description	Affected Parameter(s)	Barriers that Make Contingency Unlikely	K_{eff} Bounding Contingency (Case ID)
Double loading of singly batched containers and Flooding of chamber (20.3 cm i.d. x 27.3 cm ht)* (5 kg Pu metal)	Mass and Reflection Interaction	Operator Training, Mass control on original loading of can, Cover on counter (not completely watertight), Bottom plug is not completely watertight	0.864 ± 0.002 (CSER 98-010, case nmc8c08a)
Triple Loading of singly batched containers and Flooding of chamber (20.3 cm i.d. x 27.3 cm ht)* (7.5 kg Pu metal)	Mass and Reflection Interaction	Operator Training, Mass control on original loading of can, Cover on counter (not completely watertight), Bottom plug is not completely watertight	0.922 ± 0.002 (CSER 98-010, case nmc8c08b)

Note that all masses in the table above are 2.5 kg Pu metal buttons.

* Sizes are outer container sizes. The inner container is 8.57 cm dia. x 5.08 cm ht.

The last two cases (from CSER 98-010) include a further conservatism of including 100 g of plutonium outside of, but in contact with the can. This is because the General Limits Criticality Prevention Specification (CPS,1998) states that unless an analysis of a hood or glovebox in which material is stored indicates otherwise, then the glovebox or hood shall be assumed to contain greater than 100 g of plutonium. This additional plutonium will not be in the counter, but its inclusion in the analysis introduces a further conservatism to the NDA counter analysis.

Table 2a: Sizes of Containers used in Table 2

Analyses	Inner Can Dimensions	Outer Can Dimensions
CSER 98-010	8.57 cm dia. x 5.08 cm ht	10.8 cm dia x 17.78 cm ht
CSER 98-010	8.57 cm dia. x 5.08 cm ht	20.3 cm i.d. x 27.3 cm ht

The bounding metal case is calculated to be $k_{\text{eff}} = 0.887 \pm 0.003$ (from CSAR 80-027, Addendum 3). Analysis is of two 2.5 kg buttons of 100% ^{239}Pu with close fitting full water reflection 3.53 cm (1.39") closer than the actual sample chamber reflector. Metal button was shown to be the bounding case in section 4.2.

1.4 Limits: As determined by this CSER analysis, the following limits apply to operations utilizing this counter:

1. One container (maximum) per NDA measurement position
2. Three foot spacing edge-to-edge must be maintained between loaded NDA measurement positions³ or between any loaded NDA position and any other fissile material
3. Do not place fissile material on the top of this NDA instrument
4. Do not insert bulging or distorted fissile material outer container into this NDA instrument
5. The following mass, H/X ratio, and volume limits will apply:

Moderation (H/X)	Mass	Volume
≤ 2	$\leq 2500 \text{ g}$	$\leq 2.7 \text{ l}$
≤ 20	$\leq 1500 \text{ g}$	$\leq 2.7 \text{ l}$
unrestricted	$\leq 400 \text{ g}$	$\leq 4.7 \text{ l}$
unrestricted	$\leq 1000 \text{ g}$	$\leq 0.5 \text{ l}$

4.4 kg Pu containers are NOT allowed in this NDA instrument.

³ The measurement position is measured from the closest edge of the sample chamber.

2.0 SYSTEM DESCRIPTION

The ANTECH neutron multiplicity counter is a portable nondestructive analysis instrument. The counter is a cylindrical counter with removable plugs at the top and bottom. This dual plug design enables the counter to be used in an upright position as a well counter, i.e. with a sample that is lowered from above, as well as a pass thru counter in a horizontal position with a sample being passed into the measurement chamber horizontally. This instrument is meant to be used throughout the PFP. The operation will be simpler if the measuring instrument can be brought to the material to be measured rather than requiring the fissile material to be transported to a central NDA laboratory.

The sample chamber is a cylindrical hole in the center of the cylindrical instrument. With both plugs in place the chamber measures approximately 20.3 cm (7.99") in diameter and 33.0 cm (12.99") in length. Thus the chamber has a volume of 10.7ℓ. This volume is large enough to hold the containers listed in Section 1.3.

The radial space between the measurement chamber and the outer edge of the instrument consists mainly of polyethylene. Roughly one and a half inches out radially from the sample chamber are 24 approximately 2.54 cm (1") holes drilled axially in the polyethylene. Into these holes will be inserted neutron detectors. Approximately one inch beyond the edge of the ring of detectors is a removable cadmium liner to minimize extraneous neutrons originating from outside the detector. A radial thickness of 7.62 cm (3") of polyethylene fills out the detector to a radius of 27.7 cm (10.9"). The difference between the sum of the polyethylene thicknesses and the final radius of the detector is due to the thickness of the cadmium and the steel structure.

3.0 METHODOLOGY

NDA equipment has been employed for decades at PFP for accountability assays. During this time the criteria for criticality safety for use of this equipment has remained essentially constant. During this time several criticality safety evaluations have been performed. These are, for particle (neutron or photon) detector instruments,

- CSAR 80-001, *Barrel Counter for Nondestructive Analysis*, 16 April 1980 (WHC, 1990)
- CSAR 94-015, *New Portable NDA Equipment for use in SNM Audits*, 21 November 1994 (WHC, 1994)
- CSAR 96-005, *Canberra Barrel Counter for Nondestructive Analysis*, 18 April 1996 (WHC, 1996)

and for heat measurement instruments,

- CSAR 80-027, *Calorimeter in Room 221-B, 234-5Z Building*, 12 March 1981 RHO, 1980)
Addendum 1, 31 July 1989, *Use of Calorimeters for Fissionable Material Measurement* (WHC, 1989)

Addendum 2, 24 September 1992, *Approval of Mound Calorimeter with 8 Inch Spacing Between Measurement Chambers* (WHC, 1992)

Addendum 3, 5 December 1994, *Use of Calorimeter 109B for Fissile Material Measurement* (WHC, 1994a)

NDA equipment items identified in the current CPS in place at the time of its issuance (CPS-Z-165-80120, issued 2 April 1997) are

- calorimeters
- Neutron Well Coincidence Counters (Neutron Well Coincidence Counter and High Level Neutron Coincidence Counter)
- NaI Package Counter
- NaI Sludge Counter
- Segmented Gamma Scan Assay Systems
- Confirmatory Measurement Counter
- Multi Energy Gamma Assay System
- Portable Counters

The present instrument is a variation of these previously approved instruments. Two contingency cases were analyzed in addition to the referenced cases, using computer codes to qualify this counter.

4.0 SAFETY EVALUATION

Containers of fissile material previously analyzed for overbatching, up to doublebatching, and full water reflection for a single unit or in arrays are permitted in the chamber. Previous criticality safety evaluations of fissile-bearing containers in storage or transit at PFP analyzed for these two conditions.

CPS-2-665-80120 for NDA (CPS, 1997), which governs putting containers in this counter, allows only one container to be used with any NDA counter at any one time. This CPS is based on a series of CSERs for the NDA equipment (RHO,1980, WHC,1989, WHC, 1990, WHC,1990a, WHC, 1992, WHC,1994, WHC,1994a, and WHC,1996). The counter analyzed herein is not considered as essentially different from counters previously allowed.

The polyethylene (CH_2) reflector material surrounding the sample in the cavity has reflection properties slightly greater than those of water. Analyses with MCNP (LANL, 1993) indicate that with all other variables held constant, the use of full CH_2 reflection in intimate contact with the source is only slightly (6 mk) more reactive than full reflection with water.

With a 61.0 cm (24") thick water reflector in intimate contact with a 530 g sphere of plutonium solution at a density of 32 g/l the calculated k_{eff} was 1.00391 ± 0.00146 (input deck iZndaw). With a 60.96 cm (24") thick polythene reflector, the calculated k_{eff} was 1.00982 ± 0.00166 (input deck iZNDAeth). At the time this code was run it had been verified for Pu/moderator and water and polyethylene reflector but not validated. It had been tested against the sample runs supplied with the code, but it was not checked against benchmark cases to establish a bias. However, the absolute value is not important in this case, only the relative results. The input decks are reproduced in section 7.0.

In the counter some of the CH_2 has been removed to accommodate the detectors so that the average density of the CH_2 is less than that of water. In addition, the CH_2 is not in intimate contact with the fissionable material because the cans have a smaller OD than the ID of the counter chamber. The initial 7.62 cm (3") thickness of CH_2 consists of three equal annular regions; the first and third are solid polyethylene, while the middle region has 24 cylindrical holes of 2.54 cm (1.00") diameter drilled out with their axes parallel to the axis of the sample chamber. With this material removed the effective density of this 2.54 cm (1.00") thick annular cylindrical region is 0.53 of the density of CH_2 , or $\rho=0.48 \text{ g/cm}^3$ which is less than half that of water.

These holes in the polyethylene will be filled with detector tubes consisting of He gas and encased by thin aluminum tubing. Within the detector, the fissile sample is thus subject to the same or slightly less total reflection than that for full water which is accounted for in the CSERs for container storage or transportation under flooding conditions.

Beyond this approximately 7.62 cm (3") of CH_2 , the counter has a removable cadmium liner and then approximately 7.62 cm (3") more of CH_2 . Note that all dimensions of the CH_2 are approximate. The dimensions used herein were scaled from measurements made from the drawings and then checked with respect to the actual instrument. Thus, they are estimated to be within 0.13 cm (1/8") of the actual values and even with all of the measurement errors adding, it is less than the 30.5 cm (12") of water reflection used in the calculations. Furthermore, their total is consistent with the official drawings supplied by the manufacturer.

The CPS limits require NDA equipment spacings such that a minimum of 91.4 cm (3 ft) separation is maintained between sample chambers of different units (with the exception of calorimeters). The diameter of this instrument is approximately 73.8 cm (21.8") which is roughly one sixth of the minimum spacing requirement from the edge of the chamber to the edge of the instrument. Thus compliance with this spacing limit is an administrative control and is specified in limit 2 in section 1.3.

4.1 Base Case Conditions: The expected fissile material per container for NDA measurement falls into one of three broad H/X classes: dry fissile material ($\text{H/X} \leq 2$) limited to ≤ 2.5 kg in ≤ 4.7 l maximum containers, moderated material ($\text{H/X} \leq 20$) limited to ≤ 1.5 kg in ≤ 2.7 l maximum containers, and unrestricted moderated material limited to ≤ 0.4 kg in ≤ 4.7 l containers or ≤ 1 kg in ≤ 0.5 l containers. Only one container is allowed in the sample cavity of the counter (measurement position) at any time. The use of a dry fissile material limit of ≤ 4.4 kg per container is planned, but its use is not allowed in this counter at this time. It will necessitate a reevaluation of this counter. Only one container is allowed in the sample cavity of the NDA counter (measurement position) at any time.

These situations were analyzed in the various CSARs and CSERs listed in Section 3 (RHO,1980, WHC,1989, WHC, 1990, WHC,1990a, WHC, 1992, WHC,1994, WHC,1994a, and WHC,1996). The results listed below in Table 3 were taken from CSAR 80-027, Addendum 3 (WHC, 1994A). The model used had full water reflection but it is not always close fitting. In one case the water was assumed to have entered the container. For the doubly batched container case (two buttons in one container) it should be noted that the resultant geometry produces close to the optimal geometry ($\text{H}=\text{D}$).

The calculations used MONK6A on plutonium systems. It is possible that uranium may be present in some of the containers to be analyzed. For metal systems, ^{239}Pu bounds ^{235}U . It can also be seen in ARH-600 (ARH,1984), that for moderated ^{235}U , as long as the container diameter is less than 12.7 cm (5") the system remains subcritical. The largest containers used for fissionable material at PFP are the oversize can and the seven inch can, both of which have outer diameters less than 12.7 cm. Therefore, the analyses performed for plutonium containers to be placed in the NDA counter bounds containers containing uranium. Consideration of the bias for this code led to a k_{eff} limit for this code on the computer used of 0.935. Verification of the code is documented in the source CSARs.

Table 3: Normal and likely off-normal conditions 2.5 kg Pu metal button (Taken from CSAR 80-027, Addendum 3)	
Case	$k_{eff} \pm 0.003$
Base Case (2.5 kg Pu metal button, $H/Pu \leq 2$)	0.700
Double batched container	0.887

A more reactive situation than analyzed in previous analyses would be that of plutonium distributed throughout the sample chamber diameter as a solution. This would, however, require the rupturing of the multiple nested fissile material containers, the flooding of the sample chamber and additionally, the explosive mixing of the fissile material from the storage container with the surrounding water. This scenario with an exploding can in a flooded sample chamber is not considered as credible, but to further mitigate against its occurrence, bulging or distorted containers are not to be loaded into the counter (limit 4 of section 1.3).

4.2 Contingency Analysis: Double contingency was analyzed. The results from CSAR 80-027, Addendum 3 (WHC, 1994A) are presented in Table 4. Two additional cases were added to these results. The case involving plutonium metal is again presented since this bounds the other situations. The justification for that assumption is presented in Table 4.

In order to further extend the contingency analysis MCNP-4B was used to analyze ^{239}Pu buttons packed in two inch tuna cans which are placed in an eight inch inner diameter NMC-8 Threaded Container which is fully reflected by twelve inches of water. These cases were available because the CSER for the NMC-8 (HNF, 1999) is in preparation. The input decks referenced are reproduced in section 7. The cases where two cans and three cans are placed in the NMC-8 container are presented in Table 4. These two results are presented in the last two rows of Table 4. Validation, verification, certification, and configuration management for this code is documented in (HNF, 1998), (HNF, 1998a), (HNF, 1998b), and (HNF, 1998c).

Table 4: Normal and Contingency Conditions
 2.5 kg Pu metal button
 12" water reflection
 (Taken from CSAR 30-027, Addendum 3)

Case	$k_{\text{eff}} \pm 0.003$
Normal Case (2.5 kg Pu metal button, H/Pu $\leq$ 2)	0.700
One container with flooded chamber (1 error)	0.730
Double batched container (1 error)	0.887
One container with water in tube and container (2 errors)	0.777
Two containers each with one 2.5 kg button in a NMC-8 Container in flooded chamber (2 errors)	$0.862 \pm 0.002^*$
Three containers each with one 2.5 kg button in a NMC-8 Container in flooded chamber (3 errors)	$0.927 \pm 0.002^*$

* These data are from HNF-3533. Input decks are in section 7

Table 5 lists normal and double batched cases for various material forms of plutonium. From these results it is evident that the 2.5 kg metal button of plutonium is the bounding form.

Table 5. Comparison of normal and double batched cases for various materials with 12" water reflection outside of sample chamber (Taken from CSAR 80-027, Addendum 8)		
Case	$k_{\text{eff}} \pm 0.003$ for normal case	$k_{\text{eff}} \pm 0.003$ for double batched case
2.5 kg Pu button	0.700	0.887
2.5 kg PuO ₂ ,* 11.3 g/cm ³ , H/Pu = 2	0.698	0.872
1.5 kg PuO ₂ , 1.409 g/cm ³ , H/Pu = 20	0.592	0.739
1.5 kg PuO ₂ , 1.51 g/cm ³ , H/Pu = 20	0.640	0.775
1.5 kg PuO ₂ , 3 g/cm ³ , H/Pu = 8.676	0.504	0.670
1.5 kg PuO ₂ , 5.8 g/cm ³ , H/Pu = 3.834	0.470	0.618
400 g PuO ₂ , 0.231 g/cm ³ 4.75" dia x 6.75 l can filled with polyethylene	0.684	0.788

* This is extra dense plutonium dioxide.

5.0 CHECKLIST FOR REVIEWS CHECKLIST FOR TECHNICAL PEER REVIEW

**Document Reviewed: CSER 98-009: ANTECH NEUTRON MULTIPLICITY COUNTER
FOR NONDESTRUCTIVE ANALYSIS**

<u>Yes</u>	<u>No*</u>	<u>NA</u>	
☒	☐	☐	Problem completely defined.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	**Review calculations, comments, and/or notes are attached.
☒	☐	☐	Document approved (i.e., the reviewer affirms the technical accuracy of the document).
☒	☐	☐	Traceability

David G. Erickson
Reviewer: (Printed and Signed)

David G. Erickson

Date

1-15-1999 *dg*

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist.

TECHNICAL PEER REVIEW

Comments:

D. G. Erickson of the Criticality and Shielding group in FDNW Specialty Engineering carried out the technical peer review of CSER 98-009, Revision 0, for which the following comments are provided.

The technical arguments given in the report were found to be sound for qualifying the criticality safety of the ANTECH neutron multiplicity counter for use in NDA measurements of fissionable material at PFP. Adherence to the administrative controls given in Section 1.4 of the analysis are required to assure criticality safety. All credible contingencies resulted in k_{eff} s that are within allowables.

The review of this CSER showed that the normal condition analyses adequately and conservatively modeled the actual conditions that would be found in the ANTECH counter. Some of the conservatisms were: utilizing 100 % ^{239}Pu for all materials and using theoretical or higher material densities.

The review of the off-normal condition analysis also incorporated the above mentioned conservatisms, as well as including additional conservatisms that bound any credible off-normal operation. The analysis shows that even if the counter and container were to be flooded, containers were to be overbatched, or spacing between containers was lost, the system is still subcritical. The worst credible Plutonium density is analyzed, and shown to be acceptable. In all cases adequate margins of safety exist to assure that the operations to be performed in the counter do not pose any criticality concerns.

The report was reviewed for technical accuracy, consistency, coverage of all credible contingencies, and adequacy of limits. All editorial comments have been adequately resolved.

The input and output files from the new computer calculations were also reviewed. The input files were checked for material densities, geometry, and container volumes. The k_{eff} values reported in the report were verified against the results in the output files.

This reviewer affirms that based on the analysis contained in CSER 98-009, the operations proposed for the ANTECH neutron multiplicity counter are safe from a criticality standpoint.

Independent Review
CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: CSER 98-009: ANTECH NEUTRON MULTIPLICITY COUNTER FOR NONDESTRUCTIVE ANALYSIS

<u>Yes</u>	<u>No*</u>	<u>NA</u>	
[✓]	[]	[]	Problem completely defined.
[✓]	[]	[]	Necessary assumptions explicitly stated and supported.
[✓]	[]	[]	Computer codes and data files documented.
[✓]	[]	[]	Data used in calculations explicitly stated in document.
[✓]	[]	[]	Data checked for consistency with original source information as applicable.
[]	[]	[✓]	Mathematical derivations checked including dimensional consistency of results.
[✓]	[]	[]	Models appropriate and used within range of validity or use outside range of established validity justified.
[]	[]	[✓]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[✓]	[]	[]	Software input correct and consistent with document reviewed.
[✓]	[]	[]	Software output consistent with input and with results reported in document reviewed.
[✓]	[]	[]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
[✓]	[]	[]	Limits/criteria/guidelines checked against references.
[✓]	[]	[]	Safety margins consistent with good engineering practices.
[✓]	[]	[]	Conclusions consistent with analytical results and applicable limits.
[✓]	[]	[]	Results and conclusions address all points required in the problem statement.
[✓]	[]	[]	**Review calculations, comments, and/or notes are attached.
[✓]	[]	[]	Document approved (i.e., the reviewer affirms the technical accuracy of the document).
[✓]	[]	[]	Traceability

Reviewer: R.J. MORFORD (Printed and Signed)

Date 1-28-99

* All "NO" responses must be explained below or on an additional page.

** Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist.

Comments:

Review of HNF-3499, Rev 0

1-13-99

by

R. J. Morford

The following are comments generated from the review of HNF-3499, Rev 0 :

- 1. The limits derived (in HNF-3499, Rev 0) are adequately justified in this report**
- 2. Still need to look at both of the referenced Warren Whittekind (from CSER-98-010) runs**
- 3. Need to add figures to this report**
 - Need 4 figures at least, 1 for each problem and an x-y and x-z of at least one of the nmc8c08_ set.**
- 4. Nmc8c08_ runs were made with cell 7 above the top plane of cell 1. This is non-conservative, even though it probably will not change k_{eff} much. Need to verify this with a short run at least.**
- 5. In section 2.0, the size of all containers should be explicitly stated.**
- 6. Need to explain why the 100 g of Pu source beside the "cans" in Warren's (from CSER-98-010) runs is there.**

The above comments have been resolved and thus I approve the document

R. J. Morford

1-28-99
Date

6.0 REFERENCES

- ARH, 1984, ARH-600, Updated to 1984, *Criticality Handbook*, Atlantic Richfield Hanford Company, Richland, Washington.
- CPS, 1997, CPS-Z-165-80120, Rev/Mod B-5, *Nondestructive Assay (NDA)*
- CPS, 1998, CPS-Z-165-80010, Rev/Mod C-4, General Limits
- HNF, 1997, HNF-PRO-537, *Criticality Safety Control of Fissionable Material*, Fluor Daniel Hanford Company, Richland, Washington
- HNF, 1998, HNF-3316, Rev. 0, *Software Certification Report for MCNP4B*, Fluor Daniel Northwest, Richland, Washington
- HNF, 1998a, HNF-3317, Rev. 0, *Installation Test Verification for MCNP4B*, Fluor Daniel Northwest, Richland, Washington
- HNF, 1998b, HNF-3318, Rev 0, *Software Configuration Management Plan for MCNP4B*, Fluor Daniel Northwest Company, Richland, Washington
- HNF, 1998c, HNF-1905, Rev. 1, *MCNP4B Plutonium Validation*, Fluor Daniel Northwest, Richland, Washington
- HNF, 1999, HNF-3533, Rev. 0, CSER 98-010, *Criticality Safety Evaluation Report for Transportation of Bulged/Damaged Cans in NMC-8 Threaded Containers*, Fluor Daniel Northwest, Richland, Washington.
- LANL, 1993, LA-12625, *MCNP--A General Monte Carlo N-Particle Transport Code Version 4A*, Los Alamos National Laboratory, Los Alamos, New Mexico
- RHO, 1980, RHO-MA-165, *CSAR 80-027, Calorimeter in Room 221-B, 324-5Z Building*, Rockwell Hanford Company, Richland, Washington
- WHC, 1989, SD-SQA-CSA-20151, Rev. 0, *CSER 80-027, Addendum 1, Use of Calorimeters for Fissionable Material Measurement*, Westinghouse Hanford Company, Richland, Washington
- WHC, 1990, WHC-SD-SQA-CSA-20220, Rev. 0, *CSAR 80-001, Barrel Counter for Nondestructive Analysis*, Westinghouse Hanford Company, Richland, Washington

WHC, 1990a, WHC-SD-SQA-CSA-20228, CSAR 80-009, *Calorimeter Pre-Equilibrium Bath*, Westinghouse Hanford Company, Richland, Washington

WHC, 1992, WHC-SD-SQA-CSA-20353, CSAR 80-027, *Addendum 2, Approval of Mound Calorimeter with 8 Inch Spacing Between Measurement Chambers*, Westinghouse Hanford Company, Richland, Washington

WHC, 1994, WHC-SD-SQA-CSA-20383, Rev. 0, *CSER 94-015, New Portable NDA Equipment for Use in SNM Audits*, Westinghouse Hanford Company, Richland, Washington

WHC, 1994a, WHC-SD-SQA-CSA-20384, Rev. 0, *CSAR 80-027, Addendum 3, Use of Calorimeter 109B for Fissile Material Measurement*, Westinghouse Hanford Company, Richland, Washington

WHC, 1996, WHC-SD-SQA-CSA-504, Rev. 0, *CSER-96-005, CANBERRA Barrel Counter for Nondestructive Analysis*, Westinghouse Hanford Company, Richland, Washington

WHC, 1996a, SD-MP-SWD-30001, Rev. 8, *Certification of MCNP Version 4A for WHC Computer Platform*, Westinghouse Hanford Company, Richland, Washington

7.0 COMPUTER INPUT DECKS

Input deck iZNDaw

message:

Pu-239 for Z-Plant NDA - Water Reflector

1	1	-1.03	-1	imp:n=1	\$ Source
2	2	-1.00	-2	1 imp:n=1	\$ Reflector
3	0		2	imp:n=0	\$ End of the World

1	so	15.82	\$ Source
2	so	76.78	\$ Reflector

mode n

kcode 3000 1.0 10 100

ksrc 0.0 0.0 0.0

m1	94239.55c	-0.0291		\$ Plutonium	
	1001.50c	-0.1086	8016.50c	-0.8622	\$ Water Moderator

mt1 lwtr.01t

m2 8016.50c -0.8881 1001.50c -0.1119 \$ Water

mt2 lwtr.01t

totnu

ctme 350.

print

Input deck iZNDaeth

message:

Pu-239 for Z-Plant NDA - Polyethylene Reflector

1	1	-1.03	-1	imp:n=1	\$ Source
2	2	-0.92	-2	1 imp:n=1	\$ Reflector
3	0		2	imp:n=0	\$ End of the World

1	so	15.82	\$ Source
2	so	76.78	\$ Reflector

mode n

kcode 3000 1.0 10 100

ksrc 0.0 0.0 0.0

m1	94239.55c	-0.0291		\$ Plutonium	
	1001.50c	-0.1086	8016.50c	-0.8622	\$ Water Moderator

mt1 lwtr.01t

m2 6012.50c -0.8563 1001.50c -0.1437 \$ Polyethylene

mt2 poly.01t

totnu

ctme 350.

print

The following two input decks were contributed and run by Dr. Warren Wittekind.

Input deck nmc8c08a

message:

NMC-8 Threaded Containers for Transport of Pu, MOX, whatever

```
c 2" can CASES: Two 2" cans (2500 g each), and 100 g
c MODERATION, REFLECTION: dry inside NMC-8, 12" H2O Reflection
c -dens xx-xx yy-yy zz-zz rr-rr $ Comments
1 17 -19.470      9 -10 -17 $ 2"can contents
2 1 -0.001        9 -10 17 -2 $ 2"can empty part
3 17 -19.470     10 -18 -17 $ 2"can contents
4 1 -0.001       10 -18 17 -2 $ 2"can empty part
5 1 -0.001       9 -18 2 -1 $ NMC-8 contents
6 1 -0.001      18 -14 -1 $ NMC-8 contents
7 16 -2.214     10 -11 -4 $ 100 g fissile
8 2 -1.000      8 -9 -5 $ H2O reflector
9 2 -1.000     9 -10 1 -5 $ H2O reflector
10 2 -1.000    (-10:4:11) 10 -11 1 -5 $ H2O reflector
11 2 -1.000    11 -14 1 -5 $ H2O reflector
12 2 -1.000    14 -15 -5 $ H2O reflector
13 1 -0.001   (-8:5:15) 7 -16 -6 $ void buffer zone
14 0          -7: 16: 6 $ outside world
```

```
1 cz      10.32 $ NMC-8 inside radius (8" i.d.)
2 c/z 6.02 0.00 4.29 $ 2-inch can inside radius (3.375" i.d.)
3 c/z 4.91 0.00 5.40 $ 7-inch can inside radius (4.25" i.d.)
4 c/z 11.73 0.00 1.40 $ 100 g fissile container
5 cz      43.61 $ 12" H2O reflection around cluster
6 cz      80.00 $ Edge of Universe Boundary
7 pz     -70.00 $ Bottom of Universe Boundary
8 pz     -30.48 $ 12" H2O reflection under cluster
9 pz      0.00 $ Floor of NMC-8 container
10 pz      5.08 $ Top of 2-inch can (2" high)
11 pz     19.04 $ Height 1500 g Pu (H/Pu=20) 7-inch can
12 pz     22.07 $ Top of 7-inch can (7" high)
13 pz     27.15 $ Top of 2-inch can (2" high)
14 pz     27.46 $ Top of NMC-8 (10.81" high)
15 pz     57.94 $ 12" H2O reflection above cluster
16 pz     95.00 $ Top of Universe Boundary
17 c/z 7.47 0.00 2.837 $ Pu metal button radius (H = 2")
18 pz     10.16 $ Height 2500 g 239Pu (H/Pu=0) can +5.08
19 pz     15.24 $ Height 2500 g 239Pu (H/Pu=0) can +5.08
20 pz     20.32 $ Height 2500 g 239Pu (H/Pu=0) can +5.08
21 pz     25.40 $ Height 2500 g 239Pu (H/Pu=0) can +5.08
```

mode n

```
imp:n 1 12r 0.0
tmp 2.585e-8 12r $ 001-013 300K everywhere
1j $ 014 outside world
kcode 1000 1.0 3 100
ksrc 4.910 0.000 5.930 $ 7" can 1 low
4.910 0.000 11.850 $ 7" can 2 low
m1 1001.50c 2.00 8016.50c 1.00 $ NMC-8 Atmosphere
```

mt1	lwtr.01t		\$ 300K =27C =80.6F
m2	1001.50c 2.00	8016.50c 1.00	\$ H2O Reflector
mt2	lwtr.01t		\$ 300K =27C =80.6F
m3	94239.50c 1.00	8016.50c 2.00	\$ 239Pu O2 + H2O
c	1001.50c 0.00		\$ dens=11.460 g/cc H/Pu= 0.0
c	mt3 lwtr.01t		\$ 300K =27C =80.6F
m4	94239.50c 1.00	8016.50c 3.00	\$ 239Pu O2 + H2O
	1001.50c 2.00		\$ dens= 6.938 g/cc H/Pu= 2.0
mt4	lwtr.01t		\$ 300K =27C =80.6F
m5	94239.50c 1.00	8016.50c 3.50	\$ 239Pu O2 + H2O
	1001.50c 3.00		\$ dens= 5.882 g/cc H/Pu= 3.0
mt5	lwtr.01t		\$ 300K =27C =80.6F
m6	94239.50c 1.00	8016.50c 4.00	\$ 239Pu O2 + H2O
	1001.50c 4.00		\$ dens= 5.145 g/cc H/Pu= 4.0
mt6	lwtr.01t		\$ 300K =27C =80.6F
m7	94239.50c 1.00	8016.50c 4.50	\$ 239Pu O2 + H2O
	1001.50c 5.00		\$ dens= 4.602 g/cc H/Pu= 5.0
mt7	lwtr.01t		\$ 300K =27C =80.6F
m8	94239.50c 1.00	8016.50c 5.00	\$ 239Pu O2 + H2O
	1001.50c 6.00		\$ dens= 4.184 g/cc H/Pu= 6.0
mt8	lwtr.01t		\$ 300K =27C =80.6F
m9	94239.50c 1.00	8016.50c 5.50	\$ 239Pu O2 + H2O
	1001.50c 7.00		\$ dens= 3.853 g/cc H/Pu= 7.0
mt9	lwtr.01t		\$ 300K =27C =80.6F
m10	94239.50c 1.00	8016.50c 6.00	\$ 239Pu O2 + H2O
	1001.50c 8.00		\$ dens= 3.585 g/cc H/Pu= 8.0
mt10	lwtr.01t		\$ 300K =27C =80.6F
m11	94239.50c 1.00	8016.50c 6.50	\$ 239Pu O2 + H2O
	1001.50c 9.00		\$ dens= 3.362 g/cc H/Pu= 9.0
mt11	lwtr.01t		\$ 300K =27C =80.6F
m12	94239.50c 1.00	8016.50c 7.00	\$ 239Pu O2 + H2O
	1001.50c 10.00		\$ dens= 3.175 g/cc H/Pu=10.0
mt12	lwtr.01t		\$ 300K =27C =80.6F
m13	94239.50c 1.00	8016.50c 8.25	\$ 239Pu O2 + H2O
	1001.50c 12.50		\$ dens= 2.816 g/cc H/Pu=12.5
mt13	lwtr.01t		\$ 300K =27C =80.6F
m14	94239.50c 1.00	8016.50c 9.50	\$ 239Pu O2 + H2O
	1001.50c 15.00		\$ dens= 2.558 g/cc H/Pu=15.0
mt14	lwtr.01t		\$ 300K =27C =80.6F
m15	94239.50c 1.00	8016.50c 10.75	\$ 239Pu O2 + H2O
	1001.50c 17.50		\$ dens= 2.365 g/cc H/Pu=17.5
mt15	lwtr.01t		\$ 300K =27C =80.6F
m16	94239.50c 1.00	8016.50c 12.00	\$ 239Pu O2 + H2O
	1001.50c 20.00		\$ dens= 2.214 g/cc H/Pu=20.0
mt16	lwtr.01t		\$ 300K =27C =80.6F
m17	94239.50c 1.00		\$ 239Pu metal dens=19.47 g/cc
totnu			
ctme	480.		
print	30 40 60 110 126		

Input deck nmc8c08b

message:

NMC-8 Threaded Containers for Transport of Pu, MOX, whatever

c 2" can CASES: Three 2" cans (2500 g each), and 100 g
 c MODERATION, REFLECTION: dry inside NMC-8, 12" H2O Reflection
 c -dens xx-xx yy-yy zz-zz rr-rr \$ Comments

1 17 -19.470 9 -10 -17 \$ 2" can contents
 2 1 -0.001 9 -10 17 -2 \$ 2" can empty part
 3 17 -19.470 10 -18 -17 \$ 2" can contents
 4 1 -0.001 10 -18 17 -2 \$ 2" can empty part
 5 17 -19.470 18 -19 -17 \$ 2" can contents
 6 1 -0.001 18 -19 17 -2 \$ 2" can empty part
 7 1 -0.001 9 -19 2 -1 \$ NMC-8 contents
 8 1 -0.001 19 -14 -1 \$ NMC-8 contents
 9 16 -2.214 10 -11 -4 \$ 100 g fissile
 10 2 -1.000 8 -9 -5 \$ H2O reflector
 11 2 -1.000 9 -10 1 -5 \$ H2O reflector
 12 2 -1.000 (-10:4:11) 10 -11 1 -5 \$ H2O reflector
 13 2 -1.000 11 -14 1 -5 \$ H2O reflector
 14 2 -1.000 14 -15 -5 \$ H2O reflector
 15 1 -0.001 (-8:5:15) 7 -16 -6 \$ void buffer zone
 16 0 -7: 16: 6 \$ outside world

1 cz 10.32 \$ NMC-8 inside radius (8" i.d.)
 2 c/z 6.02 0.00 4.29 \$ 2-inch can inside radius (3.375" i.d.)
 3 c/z 4.91 0.00 5.40 \$ 7-inch can inside radius (4.25" i.d.)
 4 c/z 11.73 0.00 1.40 \$ 100 g fissile container
 5 cz 43.61 \$ 12" H2O reflection around cluster
 6 cz 80.00 \$ Edge of Universe Boundary
 7 pz -70.00 \$ Bottom of Universe Boundary
 8 pz -30.48 \$ 12" H2O reflection under cluster
 9 pz 0.00 \$ Floor of NMC-8 container
 10 pz 5.08 \$ Top of 2-inch can (2" high)
 11 pz 19.04 \$ Height 1500 g Pu (H/Pu=20) 7-inch can
 12 pz 22.07 \$ Top of 7-inch can (7" high)
 13 pz 27.15 \$ Top of 2-inch can (2" high)
 14 pz 27.46 \$ Top of NMC-8 (10.81" high)
 15 pz 57.94 \$ 12" H2O reflection above cluster
 16 pz 95.00 \$ Top of Universe Boundary
 17 c/z 7.47 0.00 2.837 \$ Pu metal button radius (H = 2")
 18 pz 10.16 \$ Height 2500 g 239Pu (H/Pu=0) can +5.08
 19 pz 15.24 \$ Height 2500 g 239Pu (H/Pu=0) can +5.08
 20 pz 20.32 \$ Height 2500 g 239Pu (H/Pu=0) can +5.08
 21 pz 25.40 \$ Height 2500 g 239Pu (H/Pu=0) can +5.08

mode n

imp:n 1 14r 0.0

tmp 2.585e-8 14r \$ 001-015 300K everywhere

1j \$ 016 outside world

kcode 1000 1.0 3 100

ksrc 4.910 0.000 5.930 \$ 7" can 1 low

4.910 0.000 11.850 \$ 7" can 2 low

m1 1001.50c 2.00 8016.50c 1.00 \$ NMC-8 Atmosphere

mt1 lwtr.01t \$ 300K =27C =80.6F

m2 1001.50c 2.00 8016.50c 1.00 \$ H2O Reflector

mt2 lwtr.01t \$ 300K =27C =80.6F

m3 94239.50c 1.00 8016.50c 2.00 \$ 239Pu O2 + H2O

c 1001.50c 0.00 \$ dens=11.460 g/cc H/Pu= 0.0

```

c      mt3      lwtr.01t      $ 300K =27C =80.6F
m4      94239.50c 1.00 8016.50c 3.00 $ 239Pu O2 + H2O
      1001.50c 2.00      $ dens= 6.938 g/cc H/Pu= 2.0
mt4      lwtr.01t      $ 300K =27C =80.6F
m5      94239.50c 1.00 8016.50c 3.50 $ 239Pu O2 + H2O
      1001.50c 3.00      $ dens= 5.882 g/cc H/Pu= 3.0
mt5      lwtr.01t      $ 300K =27C =80.6F
m6      94239.50c 1.00 8016.50c 4.00 $ 239Pu O2 + H2O
      1001.50c 4.00      $ dens= 5.145 g/cc H/Pu= 4.0
mt6      lwtr.01t      $ 300K =27C =80.6F
m7      94239.50c 1.00 8016.50c 4.50 $ 239Pu O2 + H2O
      1001.50c 5.00      $ dens= 4.602 g/cc H/Pu= 5.0
mt7      lwtr.01t      $ 300K =27C =80.6F
m8      94239.50c 1.00 8016.50c 5.00 $ 239Pu O2 + H2O
      1001.50c 6.00      $ dens= 4.184 g/cc H/Pu= 6.0
mt8      lwtr.01t      $ 300K =27C =80.6F
m9      94239.50c 1.00 8016.50c 5.50 $ 239Pu O2 + H2O
      1001.50c 7.00      $ dens= 3.853 g/cc H/Pu= 7.0
mt9      lwtr.01t      $ 300K =27C =80.6F
m10     94239.50c 1.00 8016.50c 6.00 $ 239Pu O2 + H2O
      1001.50c 8.00      $ dens= 3.585 g/cc H/Pu= 8.0
mt10     lwtr.01t      $ 300K =27C =80.6F
m11     94239.50c 1.00 8016.50c 6.50 $ 239Pu O2 + H2O
      1001.50c 9.00      $ dens= 3.362 g/cc H/Pu= 9.0
mt11     lwtr.01t      $ 300K =27C =80.6F
m12     94239.50c 1.00 8016.50c 7.00 $ 239Pu O2 + H2O
      1001.50c 10.00     $ dens= 3.175 g/cc H/Pu=10.0
mt12     lwtr.01t      $ 300K =27C =80.6F
m13     94239.50c 1.00 8016.50c 8.25 $ 239Pu O2 + H2O
      1001.50c 12.50     $ dens= 2.816 g/cc H/Pu=12.5
mt13     lwtr.01t      $ 300K =27C =80.6F
m14     94239.50c 1.00 8016.50c 9.50 $ 239Pu O2 + H2O
      1001.50c 15.00     $ dens= 2.558 g/cc H/Pu=15.0
mt14     lwtr.01t      $ 300K =27C =80.6F
m15     94239.50c 1.00 8016.50c 10.75 $ 239Pu O2 + H2O
      1001.50c 17.50     $ dens= 2.365 g/cc H/Pu=17.5
mt15     lwtr.01t      $ 300K =27C =80.6F
m16     94239.50c 1.00 8016.50c 12.00 $ 239Pu O2 + H2O
      1001.50c 20.00     $ dens= 2.214 g/cc H/Pu=20.0
mt16     lwtr.01t      $ 300K =27C =80.6F
m17     94239.50c 1.00      $ 239Pu metal dens=19.47 g/cc
totnu
ctme 480.
print 30 40 60 110 126

```

The following are pictures of the two button case (nmc8c08a). The first picture is of an x-z- elevation of the case with the cells identified. The next two pictures are of x-z- elevation and the x-y- plan of the case with the materials identified

01/11/99 14:03:02

Harvey Test Case

probid = 01/11/99 14:00:07

basis:

(1.000000, 0.000000, 0.000000)

(0.000000, 0.000000, 1.000000)

origin:

(0.00, 0.10, 8.00)

extent = (18.00, 18.00)

10

cell labels are

cell names

DISTRIBUTION SHEET

To	From	Page 1 of 1
DISTRIBUTION	FDNW Criticality and Shielding	Date 01/13/99
Project Title/Work Order		EDT No. 623018
CSER 98-009: Antech Neutron Multiplicity Counter for Nondestructive Analysis		ECN No. NA

Name	MSIN	Text With All Attach.	Text Only	Attach./Appendix Only	EDT/ECN Only
------	------	-----------------------	-----------	-----------------------	--------------

B&W Hanford Company

E. W. Curfman	T5-05	X
D. M. Fazzari	T5-06	X
R. E. Gregory	T5-08	X
S. E. Nunn	T5-11	X
A. L. Ramble	T5-54	X
M. E. Shaw	T5-54	X
R. W. Szempruch	T5-48	X
G. A. Westsik	T5-53	X

Fluor Daniel Northwest, Inc.

K. D. Dobbin	R3-26	X
D. G. Erickson	B4-44	X
J. P. Estrellado, Jr.	B4-44	X
H. J. Goldberg	B4-44	X
J. W. Hooper (3)	B4-44	X
D. S. Leach	B4-45	X
E. M. Miller	B4-44	X
R. F. Richard	B4-44	X
G. L. Rippy	T5-50	X
Central Files (Orig. + 2)	B1-07	X
Docket Files (2 copies)	A3-02	X